CHAPTER 3

STATIC ELECTRICITY PROTECTION

3–1. Discussion

a. General. While the practice of grounding electrical systems is well established, the full implications of static electricity protection are not always understood. The object of static electricity protection is to provide a means whereby static electricity charges, separated by whatever cause, may recombine harmlessly before sparking charges are attained. In order for a static electricity charge to become a source of trouble, the following conditions must be considered:

(1) There must be a means of static generation.

(2) There must be a means of accumulation of a static charge capable of producing ignition.

(3) There must be a means of spark discharge of the accumulated charge.

(4) There must be an ignitable mixture or atmosphere at location of spark discharge to constitute an explosive or fire hazard.

(5) The static potential must be maintained to constitute a hazard to personnel.

(6) The static charge must be continuously conducted to constitute a compromise of classified communications. It may be impracticable to attempt mitigation or control of all static charges. Furthermore, most static charges normally do not accumulate sufficient charge to supply enough energy to produce a spark capable of causing ignition. It should be recognized, however, that when static electricity accumulates, it becomes a potential hazard, and therefore must be controlled as required. Electrostatic electricity charges are generated by friction or contact between dissimilar conductive, semiconductive or nonconductive moving objects, materials, liquids or air particles. Obviously, we live in an electrostatic environment containing constant movement of molecules, none of which is inherently grounded. When two solids move into contact, a voltage difference or contact charge occurs. In most cases it is very small, but with tin and iron, as specific examples, it is nearly a third of a volt. The tin is electropositive in this case. Moreover, if a piece of plastic is merely pressed—not rubbed-against a metal plate and taken away, it will have a charge where actual contact was made. Whereas if the plastic is rubbed on the metal, the charges will be increased in proportion to the number of little areas which actually make contact. The plastic, being a nonconductor, tends to retain that state at any little area of contact. When an insulating solid becomes charged, the charge tends to remain anchored to the area where it was developed. Good insulators having clean dry surfaces in low atmospheric humidity can hold their charge for quite a while. A poor insulator quickly loses its charges to surrounding areas, and a good insulator having surface contamination will become somewhat conductive regardless of humidity, and will permit leakage to take place. A volume of relatively dry space which is normally a good insulator containing neutral molecules can also become charged by radioactivity andl cosmic rays. However, since there are no known perfect insulators, isolated charges of static electricity always eventually leak away. The problem is to provide instant control of hazardous accumulations of static charges without reliance upon natural bleeding or leaking away of such charges. For static electricity to discharge as a spark, the accumulated charge must be capable of jumping through a spark gap. The minimum sparking voltage at sea level is generally accepted as approximately 350 volts for the shortest measurable length of gap. Characteristics of the gap are also a limiting factor. For discharge to constitute a fire hazard, the gap must exceed a critical minimum length to permit the buildup of a sufficient energy level for an incendiary spark to result. Of course, there must be an ignitable mixture in the gap where the spark occurs. This energy level is estimated to be in order of 10^{-8} joules minimum. An example of sparking voltages required to break clown various air gap spacings is furnished in table 3–1. For calculating ignition energy, refer to NFPA No. 77.

Table 3–1. Static Electricity Sparking Voltages

Air Gap	Needle Points	½" Square Rods Cut Square	Air Gap	Needle Points	½" Square Rods Cut Square
CM	Volts	Volts	CM	Volts	Volts
0.01	(*)	(**)	1.0	12500	(**)
.05	(*)	(**)	1.5	17800	(**)
.1	(*)	(**)	2.0	23000	26000
.2	(*)	(**)	4.0	41000	47000
.5	8000	(**)	6.0	55000	62000

*Varies between 350 and 600 volts depending on air gap characteristics.

**Varies between 450 and 22,000 volts depending on air gap characteristics.

b. Sources of static electricity charges. For purposes of this manual, static electricity charges should be considered as being generated by three classifications of sources.

(1) Magnetic inductions.

(a) office equipment with moving parts as in data processing systems, having integral electric motor-driven parts assembled in a ferrous metal fireproof enclosure where the motors are grounded into the building electrical distribution system.

(b) Portable, normally ungrounded, electric motor-driven equipment having a ferrous metal enclosure exposed to operating personnel. Induced charges from magnetic induction sources could be of continuous duration at utilization voltage of electric motors.

(2) Electrostatics as defined in NFPA No. 77.

(3) Lightning static results from accumulations of extremely high voltage discharges, as discussed in paragraph 2–la. These magnitudes of potentials are sufficient to break down the dielectric strength of air for distances upwards of 3,000 feet, It will suffice to note here that lightning discharges can and do by their so-called side effects break down the dielectrics of many man-made condensers (ungrounded insulated metals, for example) existing within most of our buildings, and thereby very rapidly generate hazardous and explosive accumulations of static electricity energy in these condensers.

c. NFPA No. 77. This code suggests special studies for determining the need to provide means of preventing accumulation of static electricity in the human body. These studies include such means as: conductive flooring, use of nonmetallic supports and hardware for personnel assistance, and tie-down rings for aircraft and hydrant refueling. These means of static control are included below, as appropriate.

d. Effects of static electricity discharges. There are many reasons why concerns for protection against static electricity charges are important. Most of the everyday, normal types of static charges find a quick natural means of dissipation without any hazardous effects. However, because static charges of instantaneous magnitudes greater than 10 kilovolts may be encountered, it is mandatory that potential effects from accumulations of these charges be considered. This is particularly essential where personnel are involved and where such static discharges may occur in hazardous areas with sufficient strength to produce ignition. It is not the intent herein to provide a listing of effects of discharges of static electricity, as many are already well known. It is the intent, however, to place every electrical designer on the alert to use every reasonable precaution for including static electricity protection in each project specification when such protection is required.

e. Resistances to ground. Resistance to ground for dissipation of static electricity charges is not critical in order to provide adequate leakage path to ground and to equalize static electricity charges as fast as they are generated. Resistance to ground for static electricity dissipation may be as much as 1,000,000 ohms. However, resistances to ground of less than 25,000 ohms should be avoided when used with the usual g-rounded electrical distribution system in order to avoid increased electric shock hazard to personnel which may result in using lower resistances to ground. Maintaining an average range of between 25,000 to 100,000 ohms resistances, to limit the current magnitude to ground, is complicated by ambient wet or dry conditions, such as: atmospheres, building materials, and foundations of concrete or earth, Resistance to ground limitations will be established for corresponding applications herein.

3–2. Applications

a. Conditions. It is not the intent of this manual to attempt to furnish a listing of all applications where static electricity protection should be provided. The electrical designer must analyze suspected potential static electricity charges and decide what conductive paths will be available between them, particularly in the following conditions:

(1) Hazardous locations as listed in the NFPA No. 70.

(2) Locations containing hazardous materials which will be handled or stored.

(3) Movable and portable equipment having static electricity generating capabilities which will be dangerous to personnel,

b. Hospitals. Static electricity protection in intensive care, and surgical and obstetrical sections of hospitals will conform to NFPA No. 56A.

c. Other facilities. Static electricity protection for other facilities will be in conformance with provisions included below, unless otherwise requested on a project-by-project basis by the using service. Where criteria of other Federal agencies conflict with criteria contained below, the most stringent criteria will govern.

3–3. General. Building areas where static electricity protection is required will be identified on the contract drawings in conformance with classifications contained in NFPA No. 70. A listing of hazardous materials, containers, and operating units will be included in the design, and fixed operating equipment locations indicated on the drawings. Portable and movable equipment requiring static electricity grounding will be distinctively identified by location and with type of grounding locations required.

3-4. Bonding

a. Bonding is the process of connecting two or more conductive objects together by means of a conductor. Bonding is done to minimize voltage differences and impedances of joints. Bonding conductors normally will be uninsulated. When bonding conductors are used between movable objects, and connections are disconnected frequently, they will be of the flexible conductor or strap type. When concealed or mechanically protected, bonding conductors may be No. 10 AWG copper wire; otherwise No. 6 AWG copper wire or larger will be used. Bonding for other facilities will conform with NFPA No. 70, and U L 467, unless otherwise required in paragraph 3-9. The following guide will be used for determining objects to be bonded, in conformance with paragraph 3-2:

—For permanently installed underground built-in equipment having metal housing and movable or portable equipment having ungrounded metal housing; bond to attached or unattached fixed adjoining metal.

—For movable or portable equipment normally having ungrounded metal housing located in room or area where protection of operating and maintenance personnel is required regularly; provide conductive flooring as described below.

—For movable or portable normally ungrounded equipment having nonconductive housing and no accessible grounding terminal; provide bonding terminal for portable type connection.

—For classified equipment; bond in conformance with paragraph 3–9. Electrically conductive containers with explosive and flammable contents shall be grounded. In bonding explosive and flammable contents of containers, including nonconducting liquids stored in electrically insulated containers, it may be necessary to insert a conductive electrode having a bonding terminal on the exterior of the container. The electrode material will be chemically inert to the stored ingredients and the container. Such an arrangement will be specified only by the using service. Whenever such electrode is used, it will be of a designed which will preclude its being broken off during handling of containers.

b. Before securing any bond, it is necessary to insure electrical continuity by removing any paint, oil, dirt or rust to present an electrically clean contact surface. In providing a bond for a frequently moving body such as a metal door, hinged shelf or table, not less than two separated flexible bonding straps will be provided. Bonds will not be made to gas, steam, oil, air, or hydraulic lines, nor to sprinkler system piping or metallic bodies connected to lightning protection system, except as required below finished grade, as described below.

3–5. Grounding. Grounding is the process of connecting one or more metallic objects and g-rounding conductors to a ground electrode or system. A metallic object also may be grounded by bonding to another metallic object that is already connected to the ground. Grounding conductors within the building will be bonded separately to static electricity bonding jumpers or other bonded metals, and connected below finished grade to an appropriate grounding electrode or system. No fewer than two grounding conductors will be provided for connection to grounding electrodes at opposite corners of any building. For buildings having more than a total of 1,600 square feet of protected area, one grounding conductor-electrode arrangement will be provided at each corner of the building. Steel framing members of the building and metal sides that are electrically bonded and not used for lightning protection may be as part of the grounding conductor system. Ground rods will be not less than 5/8 inch in diameter, 8-foot long copper or copper-clad rods driven so tops are not less than 6 inches below finished grade, except as otherwise required herein. The electrical power grounding system will be extended and connected to the static electricity grounding system.

3–6. Hazardous locations. Electrical design will incorporate the requirements of the using service relative to hazardous materials, equipment and containers to the extent that information is furnished to enable the construction contractor to proceed with full understanding of static electricity protection provisions. Classifications will conform to NFPA No. 70, unless otherwise authorized by the using service. For Air Force facilities, classifications of hazardous areas of hangars, docks and POL areas will conform to AFM 88-15. For Army facilities, classifications for POL areas will conform to AR 415-22.

3–7. Petroleum oil lubricants (POL) facilities. This paragraph pertains to static electricity protection for pumping, distribution, fueling and refueling storage and miscellaneous handling facilities for Army facilities. Fueling and refueling of fixed wing aircraft on the ground is discussed in paragraph 3–11. Recommendations contained in NFPA No. 77, will be included in each project design of these facilities as appropriate. Prior to and during fueling of other than fixed wing aircraft, the refueling hose nozzle must be bonded to the plane by means of a short bond wire and clip, without reliance upon a separate static electricity grounding system. Air Force designs will be in accordance with the requirements of AFM 85-16.

3–8. Weapon systems. Where electromagnetic pulse (EMP) or electromagnetic sheilding protection is included in the design of any weapons system, grounding conductors of the static electricity protection systems, when required, will be bonded to these other protective systems at convenient locations below finished grade. Separate static electricity protection is not required for static producing units such as doors, fixed or movable equipment, electric motors, and storage containers, when these items are bonded electrically to other grounding type of protection system. When question arises whether static electricity generating sources may be controlled, these units will be bonded to a grounding system to assure safety of personnel and prevent malfunction and breakdown of weapons system tactical control functions. Weapons system support facilities provisions for static electricity protection will conform to above general requirements.

3-9. Classified communications buildings. Classified communications cannot risk being compromised and endangered by permitting ungrounded static electricity discharges. Static electricity generating equipment used in classified communications operations will be bonded to a grounding system separate from other grounding systems in accordance with MIL-HDBK-419 and MIL-STD-188-124. This is required to insure complete invulnerability to intelligence countermeasures from any possible potential static electricity discharge, No fewer than two shielded grounding buses will be provided within each classified room or area. Not more than two such grounding buses will be connected by shielded conductor to one electrode below finished grade, Grounding buses will be arranged with a number of shielding one-wire grounding receptacles to provide a plug-in grounding jack (telephone type) connection for each classified unit of equipment, Grounding of other than classified equipment to these grounding buses will be permitted. Ground rods will be driven into earth so that tops and connections thereto will be not less than 2 feet below finished grade.

3-10. Corrugated steel arch type igloos for storage of MB-1, GAM-87 and GAR cased propellant type weapons. Static electricity grounding of case will be bonded to the lightning protection grounding electrodes. This arrangment will permit no space between cased weapons and storage racks for possibility of any static spark.

3-11. Airplane parking aprons. Static electricity grounding in new construction for airplane parking-hydrant refueling areas will be accomplished with a closed metal tie-down ring, 1% inch inside diameter, welded to the reinforcing steel in the concrete, Parking apron will be provided with a recess cavity at each ground rod location, permitting top of tie-down ring to become set below apron surface. The recessed cavity will be wide enough to permit static grounding temporary connections to metal tie-down ring. Resistance to ground of each tie down ring connected to the reinforcing steel can be anticipated to be less than 10,000 ohms. In hydrant refueling areas one static grounding tie-down ring will be installed between each refueling hydrant and electrical cable control box. Tie-down ring grounding electrode interconnections between hydrant and cable housing will not be required. Static grounds are not designed for aircraft lightning protection.

3-12. Airplane hangar floors. Grounding devices installed in floors are intended to serve for airplane static and equipment grounding. A static grounding system conforming to NFPA No. 77 is suitable for dissipation of any aircraft static electricity to ground. However, inasmuch as NFPA No. 70 requires a maximum of 25 ohms resistance to ground for equipment grounding, the 25-ohms requirement will govern for this dual-purpose grounding system. Floor grounding systems electrodes will be interconnected below concrete, and interconnection also will be made to hangar electrical service grounding system. Interconnections will be of not less than No. 4 AWG bare copper. Each floor receptacle will consist essentially of a housing, grounding connection stud, housing cover, and ground rod as illustrated in figure 3-1. Floor layouts for receptacles will be essentially as follows:

a. Where hangars will be used for a specific number and type of aircraft, one grounding electrode will be provided for each aircraft space approximately 10 feet from the centerline of the aircraft space in the vicinity of one of the main landing gears.

b. For general purpose hangars, electrodes will be provided for each aircraft space approximately 10 feet from centerline of the aircraft space, and will be installed at 50-foot intervals. Spacing of electrodes from wall lines or columns will not exceed 50 feet.

3-13. Conductive flooring. Where conductive flooring is provided in an area of a room, it is not necessary to provide separate grounds for metal frames of nonelectric equipment located on that flooring. Conductive floors are provided essentially to protect operating and maintenance personnel from hazards of shock where personnel may otherwise become exposed to low resistances to ground (less than 25,000 ohms), at voltages of electrical distribution system, or other hazardous area system, The following guide may be used in identifying hazardous conditions and materials requiring conductive flooring for protection of personnel from static electricity:

a. Areas containing units of operating equipment hazardous to operating and maintenance personnel.

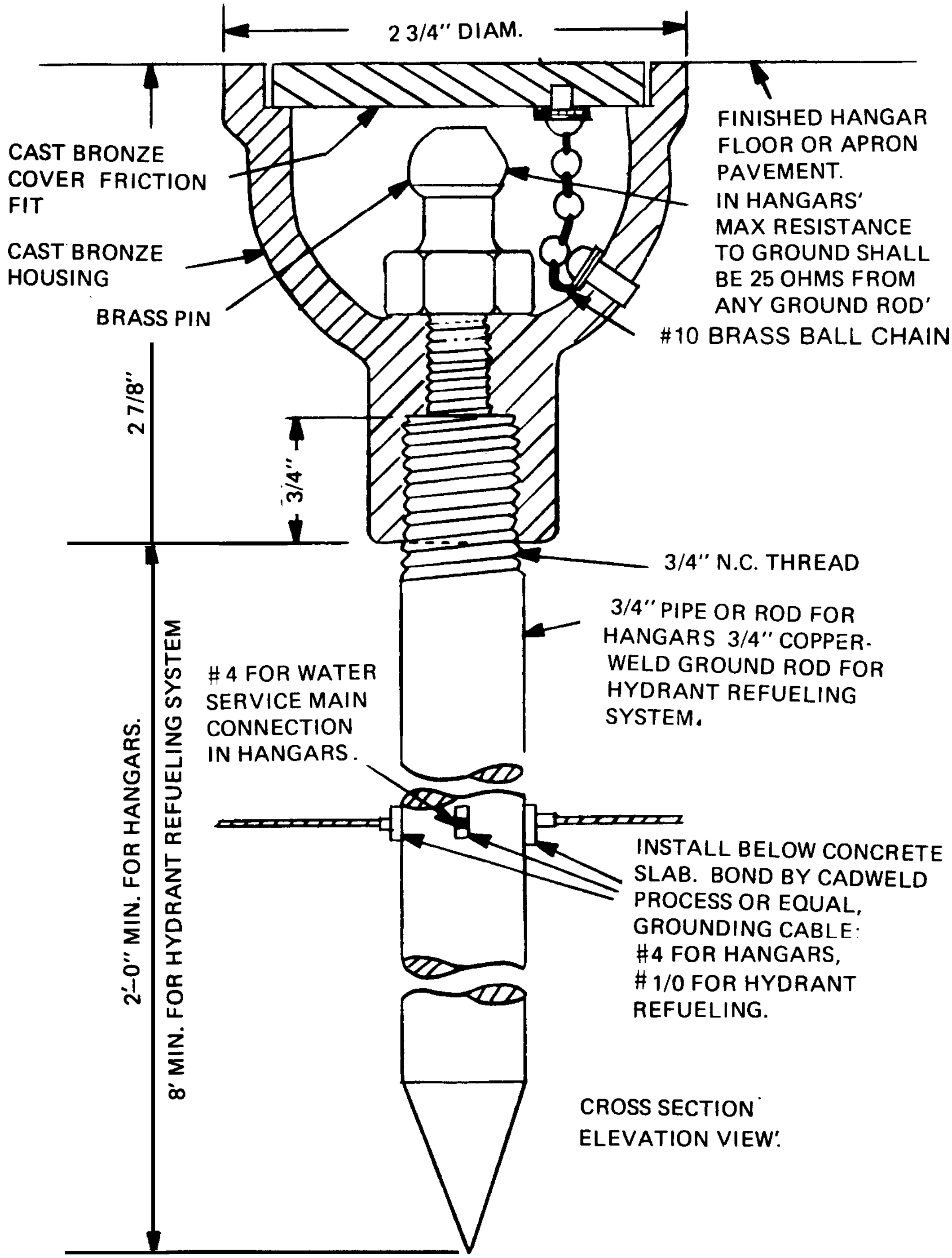

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Figure 3-1. Static grounding receptacle *b. Hazardous materials including the following:*

(l) Loose unpacked ammunition with electric primers.

(2) Exposed electro-explosive devices such as: squibs, detonators, etc.

(3) Electrically initiated items with exposed electric circuits such as rockets.

(4) Hazardous materials that could be easily ignited or detonated by a static spark such as—

Lead styphnate.	Ethyl ether.
Lead azide.	Ethyl alcohol.
Mercury fulminate.	Ethyl acetate.
Potassium chlorate-lead styphnate mixtures.	Tetrazene. Diazodinitrophanal.
Grade B magnesium powder.	Igniter composition.
Black powder dust in exposed layers,	Acetone.
Dust of solid propellants, uncased.	Gasoline.
Dust-air mixtures of ammonium picrate, tetryl, and tetrytel.	Anesthetics.

c. Storage areas containing exposed explosives, such as—

Primers.	Igniters.
Initiators.	Tracers.
Incendiary mixtures.	Detonators.

Information in connection with specific hazardous materials as listed above and units of hazardous equipment will be obtained from the using service for each project. Hazards of dust-air or flammable vapor-air mixtures can be reduced substantially by providing for adequate housekeeping, dust collection, ventilation, or solvent recovery methods.